Is tillering efficiency a relevant trait in selecting for high yield potential in rice?

Improving yield potential in rice implies the characterization of particular crop traits that may be used by breeders in their breeding programs. The rice crop is known to initiate and develop many tillers; a significant part of this may be higher than 50%, do not produce any grain. Recent breeding programs for yield potential have selected genotypes with high tillering efficiency (low tiller mortality) such as new plant types to reduce dry matter loss (Schnier et al 1990) and respiration cost (Dingkuhn et al 1990), but they did not produce the expected high yield in experimental fields. A positive correlation of grain yield with tillering efficiency would also imply a detrimental effect of non-productive tillers. We reviewed here a number of our recent field works to characterize the correlation between grain yield and tillering efficiency across genotypes of the same crop duration grown in similar favorable conditions and across crop managements for the same genotype.

Results

- **No positive correlation between grain yield and tillering efficiency, ε_t, was observed across high-yielding hybrids and elite lines (Fig. 1) and across elite parental lines and their progenies introgressed with low tiller gene (Fig. 2) grown in similar conditions**.

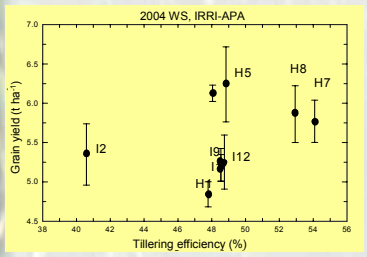


Fig. 1. Effect of ε_t on GY during 2004 WS in IRRI transplanted at 50 plants m^{-2} (12.5 kg ha^{-1}).

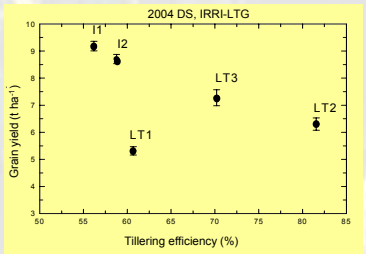


Fig. 2. Effect of ε_t on GY during 2004 DS in IRRI Using low tiller gene introgressed lines transplanted at 25 plants m^{-2} (6.25 kg ha^{-1}).

- **No positive correlation between grain yield and ε_t was observed across elite lines and hybrids either transplanted or direct-seeded (Fig. 3).**

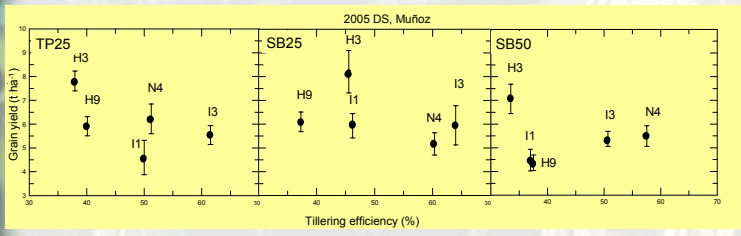


Fig. 3. Effect of ε_t on GY during 2005 DS in Muñoz either transplanted at 100 pl m^{-2} (25 kg ha^{-1}) (TP25), broadcast at 100 plants m^{-2} (25 kg ha^{-1}) (SB25) or broadcast at 200 plants m^{-2} (50 kg ha^{-1}) (SB50).

- **No positive correlation between grain yield and ε_t was observed across elite lines and hybrids transplanted at 7, 14 or 21d after sowing (Fig. 4).**

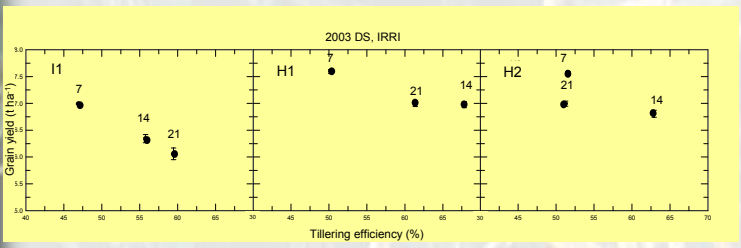
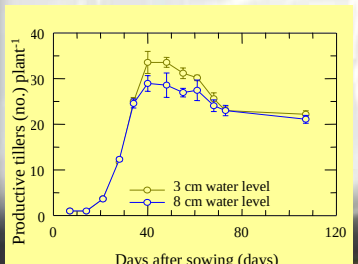


Fig. 4. Effect of ε_t on GY during 2003 DS in IRRI transplanted at 7, 14 and 21 DAS at 25 plants m^{-2}.

- **Grain yield was not increased when ε_t was increased by change in water depth (Fig. 5) while not affecting any other trait during plant growth.**



This is presented for I1 and was also valid for H1 and N4.

H_2O depth (cm)	Tillering efficiency (εt) (%)	Grain yield (t ha^{-1})
3	67	6.9 ± 0.15
8	76	6.6 ± 0.12

Fig. 5. Effect of water depth on the number of productive tillers during 2004 DS in IRRI transplanted at 25 plants m^{-2} (6.25 kg ha^{-1}).

Materials and methods

Wet season 2004, IRRI
High-yielding hybrids
H1 : IR75217H
H5 : IR78386H
H7 : IR79175H
H8 : IR80793H
High-yielding inbreds
I1 : IR72
I2 : IR64
I9 : IR 77958-7-4-3 (A2502)
I10 : IR77958-14-4-7 (A2504)
I12 : IR76928-74-3-2-1 (A2568)

Dry season 2005, Muñoz
High-yielding elite lines
I1: IR72
I3: PSBRc82;
High-yielding hybrids
H3: SL-8
H9: Bigante
New plant type
N4: IR72967-12-2-3

Dry season 2004, IRRI
I1: IR72
H1: IR71676-90-2-2
H2: IR75217H
Water depth
• 3 cm } from mid-tillering to
• 8 cm PI.

Dry season 2004, IRRI
High-yielding elite lines
I1: IR72
I2: IR64
Low tiller gene introgressed lines with IR64 or IR72 background
LTG1
LTG2
LTG3

Dry season 2003, IRRI
I1: IR72
H1: IR75217H
H2: IR68284H
Age of seedlings:
7, 14 and 21 days

εt = PTil / MaxTil,
where εt is tillering efficiency, PTil is the number of productive tillers per unit soil area at maturity, and MaxTil is the highest number of tillers per unit area observed during plant growth with weekly samplings

- **A positive correlation between grain yield and early crop vigor (as LAI here, but also valid with early tiller number and shoot dry matter) was observed when either the rate (Fig. 6) or beginning of (Fig. 7) tiller emergence was strongly different between cases.**

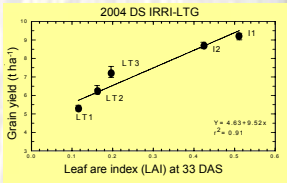


Fig. 6. Effect of leaf area index (LAI) at early growth stage on grain yield using elite lines and low tiller gene introgressed lines during DS 2004 IRRI.

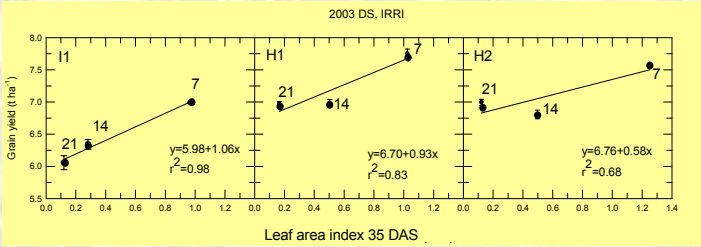


Fig. 7. Effect of early leaf area development as (LAI) on grain yield during 2003 DS, IRRI.

Conclusion

No positive correlation was observed between grain yield and tillering efficiency across high-yielding genotypes grown in the same favorable conditions and across crop management strategies for the same genotype. In contrast, in cases when the rate or start in tiller emergence was strongly affected by either genetic potential or crop management, then a strong correlation was observed between grain yield and any crop traits that represented early crop vigor.

Tillering efficiency did not appear as a relevant trait to select for high yield potential in rice. Other key traits should be considered such as early crop vigor, expressed here as rapid leaf area production, and possibly dry matter accumulation and carbohydrate remobilization during grain filling, in the case of high-yielding genotypes with early crop vigor. In fact, nonproductive tillers were the smallest of the canopy and may not have then competed significantly for access to light with productive tillers but were still able to intercept light not captured by productive tillers. The impact of nonproductive tillers on grain yield through dry matter remobilization should be quantified in further studies.

References

Dingkuhn M, Schnier HF, De Datta SK, Wijangco E, Dorffling K. 1990a. Diurnal and developmental changes in canopy gas exchange in relation to growth in transplanted and direct-seeded flooded rice. Aust. J. Plant Physiol. 17: 119-134.

Schnier HF, Dingkuhn M, De Datta SK, Mengel K, Wijangco E, Javellana C. 1990. Nitrogen economy and canopy carbon dioxide assimilation of tropical lowland rice. Agron. J. 82: 451-459.

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